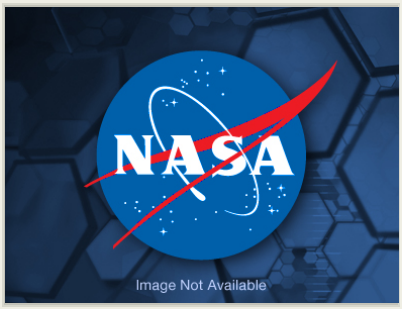
Monitoring the High-Energy Radiation Environment of Exoplanets around Low-mass Stars with SPARCS (Star-Planet Activity Research CubeSat)

Completed Technology Project (2018 - 2021)

Project Introduction

Seventy-five billion M dwarfs in our galaxy host at least one small planet in the habitable zone (HZ). The stellar ultraviolet (UV) radiation from M dwarfs is strong and highly variable, and impacts planetary atmospheric loss, composition and habitability. These effects are amplified by the extreme proximity of their HZs (0.1–0.4 AU). JWST will characterize HZ M dwarf planets and attempt the first spectroscopic search for life beyond the Solar System. Knowing the UV environments of M dwarf planets will be crucial to understanding their atmospheric composition and a key parameter in discriminating between biological and abiotic sources for observed biosignatures. The UV flux emitted during the super-luminous pre-main sequence phase of M stars drives water loss and photochemical O2 buildup for terrestrial planets within the HZ. This phase can persist for up to a billion years for the lowest mass M stars. Afterwards, UV-driven photochemistry during the main sequence phase strongly affects a planet's atmosphere, could limit the planet's potential for habitability, and may confuse studies of habitability by creating false chemical biosignatures. Our proposed CubeSat observatory will be the first mission to provide the time-dependent spectral slope, intensity and evolution of M dwarf stellar UV radiation. These measurements are crucial to interpreting observations of planetary atmospheres around low-mass stars. Mission: The Star-Planet Activity Research CubeSat (SPARCS) will be a 6U CubeSat devoted to monitoring 25 M stars in two UV bands: SPARCS far-UV (S- FUV: 153–171 nm) and SPARCS near-UV (S-NUV: 260– 300 nm). For each target, SPARCS will observe continuously between one and three complete stellar rotations (4–45 days) over a mission lifetime of 2 years. A UV characterization survey of M dwarfs, the most common of planet hosts, is a perfect experiment for a CubeSat: -- UV astronomy cannot be done from the ground because of Earth's atmospheric absorption. -- Photometry of nearby sources is an efficient use of a small aperture. -- Unlike the HST, whose time is shared among many instruments and programs, a CubeSat can provide dedicated space-based long-term monitoring in the UV. Technology: SPARCS will advance UV detector technology by flying high quantum efficiency (QE), UV-optimized detectors developed at JPL. These “delta-doped” detectors have a long history of deployment demonstrating greater than 5x the sensitivity of the detectors used by GALEX. SPARCS will pave the way for their application in missions like LUVOIR or HabEx. Education: The SPARCS research program will train future scientists and mission leaders by mentoring five undergraduate students, three graduate students, and two post-doctoral scholars throughout all aspects of the mission, including engineering, science, data management and outreach. Relevance to NASA: The SPARCS mission will address NASA's goals of identifying the characteristics and distribution of potentially habitable environments, including HZ planet hosts like Proxima and TRAPPIST-1. SPARCS will also be capable of ‘target-of-opportunity’ UV observations of NASA's TESS yield of rocky planets in M dwarf HZs, some of the first HZ



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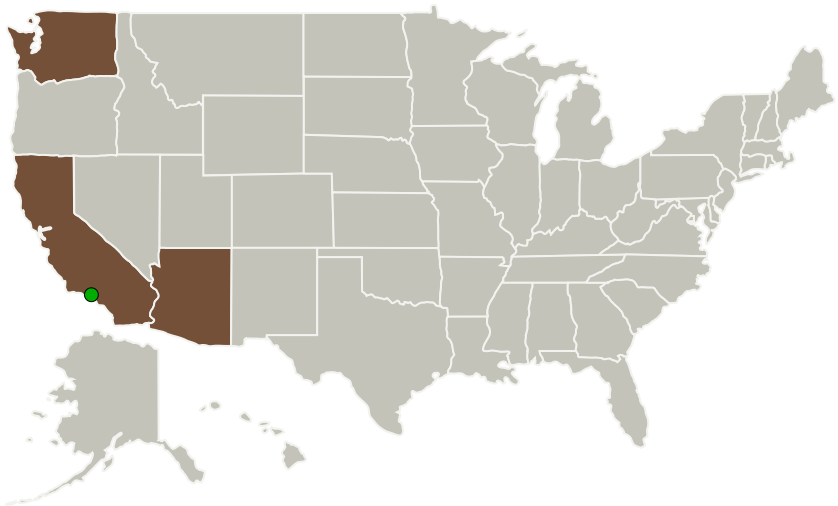
planets to be spectroscopically characterized by JWST. SPARCS can provide the needed UV context for the interpretation of transmission and emission spectra of these potentially habitable planets. Further into the future, SPARCS results will inform the target strategy for the enormous telescopic investments in exoplanet science of LUVOIR or HabEx. SPARCS' technology will fill a gap in NASA's capabilities to observe low-mass stellar/planetary systems in the FUV and NUV. HST's UV capabilities will not last much later than 2019, with future opportunities (e.g., LUVOIR) not arriving until sometime after 2035. The detector technology of this CubeSat will play a crucial role in these and interim UV-capable missions.

Anticipated Benefits

The Astrophysics Research and Analysis program (APRA) supports suborbital and suborbital-class investigations, development of detectors and supporting technology, laboratory astrophysics, and limited ground based observing. Basic research proposals in these areas are solicited for investigations that are relevant to NASA's programs in astronomy and astrophysics, including the entire range of photons, gravitational waves, and particle astrophysics. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

Arizona State University-Tempe (ASU)

Responsible Program:

Astrophysics Research and Analysis

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Evgenya L Shkolnik

Continued on following page.

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Organizations Performing Work	Role	Type	Location
Arizona State University-Tempe(ASU)	Lead Organization	Academia	Tempe, Arizona
California Institute of Technology(CalTech)	Supporting Organization	Academia	Pasadena, California
Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California
Lowell Observatory	Supporting Organization	Industry	Flagstaff, Arizona
Office for Research and Sponsored Projects Administration - Arizona State University(ORSPA)	Supporting Organization	Academia	Tempe, Arizona
Planetary Resources Development Corporation	Supporting Organization	Industry	Bellevue, Washington
University of Arizona	Supporting Organization	Academia Hispanic Serving Institutions (HSI)	Tucson, Arizona
Washington University in St Louis	Supporting Organization	Academia	Saint Louis, Missouri

Primary U.S. Work Locations	
Arizona	California
Washington	

Project Management *(cont.)*

Co-Investigators:

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Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System